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Vulnerability Assessment in case of changing climate in Himalayan region

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Abstract

Climate change is a natural process that is being accelerated alarmingly by anthropogenic and technogenic activities. Climate change potentially threatens life, property, environmental quality and future prosperity of a region by increasing the risk of storms, landslides, droughts, flooding and heat waves. Climate change can enforce migration of human population specifically in the fragile Himalaya by steady depletion of surface and groundwater resources. One of the main challenges of the next decades is to find the Sustainable Development path, ensuring economic prosperity is linked to social progress and environmental protection. The urgency of addressing the humanitarian consequences of climate change is evident and actions to address these risks need to be ambitious. The people of Uttarrakhand persistently live under the threat of landslides caused by extreme rainfall events such as cloud burst and

recurrent tectonic activities. The landslides not only take their toll on the life and property of the people of Himalaya but they also almost routinely paralyze the traffic at least for a couple of days during the monsoons the consequences of blockage in the trunk arteries of transport cannot be overemphasized.

Key words: Anthropogenic; Climate Change; Economic prosperity; Environmental protection; Landslides; Sustainable development; Tectonic activities.

Introduction

Among the global mountain system, the Himalaya is the most complex and diversified, and separates the northern part of the Asian continent from South Asia. The region being a discrete geographical and ecological entity, figures prominently in major biophysical settings of the planet earth. This vast mountain range produced a distinctive climate of its own and influences the climate of much of Asia. Climate change in the Himalayan region is critical because it will impact not only the environment of the mountains themselves but also the large and highly populated areas adjacent in the plains. The effects on glaciers have been very much in the public mind (as well as the scientific literature) recently, owing to an unfortunate quotation of a non-refereed source in an

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IPCC document, but other very important aspects of climate change in the Himalayan region have hardly received any attention. There is a need to develop a network for long-term data collection on various ecological and socio-economic aspects, not only of the Himalayan region but of the connected river basins, too. Many Himalayan countries do not have adequate scientific systems in place to do this research. And because of war, conflict and insurgencies, scientific cooperation between countries and regions is unlikely to improve. Evidently the politically unstable Himalayas are going to be one of the most vulnerable regions of the globe to climate change. We need to act quickly and take advantage of existing solutions to prevent irreversible damage to our planet. Natural ecosystems provide significant opportunities to cut emissions dramatically and to preserve the adaptive potential of our biosphere.

At the national level, increase of –0.4ºC has been observed in surface air temperatures over the past century. The global warming might severely affect the river connection between the Himalayas and Gangetic Plains, and climate regime of the entire region. Most of the talk on climate change in the Himalayas is centered on glaciers melt. How natural ecosystems and agriculture are going to be affected is hardly considered.

Biodiversity and its Importance

Biodiversity reflects the number, variety and variability of living organisms. It includes diversity within species, between species, and among ecosystems. The concept also covers how this diversity changes from one location to another and over time. Indicators such as the number of species in a given area can help in monitoring certain aspects of biodiversity. Many seasonal processes are also affected by global warming. We are starting to witness:

- Earlier leaf production by trees.
- Earlier greening of vegetation.
- Changed timing of egg-laying and hatching.
- Changes in migration patterns of birds, fish and other animals.

Reductions and re-distributions in populations of algae and plankton; this threatens the existence of fish and other animals that rely on algae and plankton for food.

Rises in concentrations of carbon dioxide

The basic ingredients of photosynthesis are carbon dioxide and water. Increased carbon dioxide in the atmosphere causes increased growth rates in many plant species. This is good news for farmers, but only if this carbon dioxide 'fertilization' effect is matched by adequate soil moisture and other nutrients. Leaf-eating animals may not be so lucky: increased concentrations of carbon dioxide could diminish the nutritional value of foliage. Rising levels of atmospheric carbon dioxide could also decrease the calcification rates of corals, meaning that reefs damaged by bleaching or other agents would recover more slowly.

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National Mission for sustaining the Himalayan ecosystem

The Himalayan ecosystem is vital to the ecological security of the Indian landmass through providing forest cover, feeding perennial rivers that are the source of drinking water, irrigation, and hydropower, conserving biodiversity, providing a rich base for high value agriculture, and spectacular landscapes for sustainable tourism. At the same time, climate change may adversely impact the Himalayan ecosystem through increased temperature, altered precipitation patterns, and episodes of drought. It is accordingly necessary to continue and enhance monitoring of the Himalayan ecosystem, in particular the state of its glaciers, and the impacts of change in glacial mass on river flows. Since several other countries in the South Asian region share the Himalayan ecosystem, appropriate forms of scientific collaboration and exchange of information may be considered with them to enhance understanding of ecosystem changes and their effects. It is also necessary, with a view to enhancing conservation of Himalayan ecosystems, to empower local communities, in particular through the Panchayats, to assume greater responsibility for management of ecological resources.

Our solution: Protection and sustainable management of natural ecosystems

Protecting the Earth's ecosystems can yield immediate, cost-effective climate change solutions that will be forever lost if we do not take immediate action. For example, the burning and clearing of tropical forests is a major – though often unrecognized – source of greenhouse gas emissions. It accounts for roughly 16 percent of total global emissions, more than all of the world's cars, trucks, ships, trains and planes combined. It is now generally recognized that it will be impossible to achieve any of the needed targets for mitigating climate change without significantly curbing the clearing and burning of tropical forests. In fact, reducing global deforestation by 50 percent by 2020 offers nearly one-third of the cost-effective, technologically available options to meet 450 ppm stabilization targets. In addition, intact forests and other natural ecosystems – including wetlands, peatlands, coral reefs and mangroves – also reduce the risk of catastrophic impacts like floods and droughts, contribute to food and freshwater security for both rural and urban communities, allow for species migration and ecological adaptation, and support the livelihoods of indigenous and local communities. Maintaining these ecosystems will ensure that humans and other species can remain as resilient as possible to the impacts of climate change.

Natural ecosystems play an essential role in human health security by regulating climate, air, water and infectious diseases as well as supplying effective disease treatments, which is why CI has made health security one of its new priorities. Globally, more than 50 percent of modern medicines and more than 90 percent of traditional medicines come from wild plants and animals. More than 70,000 plant species are used as medicine, making up "one of the most significant ways in which humans directly reap benefits

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provided by biodiversity," according to the United Nations Environment Programme. Many of the leads for treatments of cancer, HIV/AIDS, Alzheimer's, diabetes and many other life-threatening diseases are coming from the marine ecosystems in coral reefs. While many pharmaceutical companies have relied in recent years on searching their own libraries for new medicines, these explorations have proved disappointing. In fact, the overall diversity of medicinal compounds in nature is 100 million times greater than that in existing synthetic libraries, according to the National Cancer Institute.

Mountains are known to influence the livelihoods of nearly 40 per cent of people globally. Covering about 24 per cent (35.8 million km^2) of the world's land surface, mountains are home to 28 per cent of the planet's closed forests. Nearly 500 million people live in the adjacent Gangetic plains, where agriculture has been practiced for several thousand years using water from these mountains. In the future, global warming may well severely affect the river connections between the Himalayas and the Gangetic plains, and hence the climate regime and food production capacity of the entire region. This paper is more concerned with the question of how natural ecosystems and agriculture are going to be affected, issues that have hardly been considered in the scientific literature, in spite of the fact that they have been recognized in the action plan of India's Prime Minister on climate change (Government of India, 2008), which listed these impacts on mountains as being among the priority research areas. This paper begins with a preliminary account of evidence of climate change in the region, and continues by looking at impacts of this in the areas of water flows and alpine ecosystems. It goes on to discuss the role of the Himalayas as a biological refuge in a changing climate, phenological (seasonal) changes that are occurring, tree water relations and the regeneration of dominant species. The paper then turns to the human impacts of climate change in the region, and discusses the spread of disease and impacts on agriculture.

Observed and expected impacts of climate change in the Himalayas and surrounding areas

The Himalayas are a major geo-ecological feature of the planet. Not only is the highest mountain, Everest, found here, but also nine of the world's 14 tallest peaks. The evolution of the monsoon rainfall pattern of the whole of Asia is attributable to the presence of these mountains. The high mountain ranges intercept cold winds from the north and trap moisture from the winds rising from oceans in the south. The limited data that are available indicate that the Himalayas seem to be warming several times more than the global average rate (Shrestha *et al*., 1999; Liu and Chen, 2000), that temperature increases are greater during the winter and autumn than during the summer; and that increases are larger at higher altitudes (Liu and Chen, 2000). It is not in doubt that the effects of global warming have major consequences with respect to impacts on all aspects of the environment and human welfare, and many of these impacts are likely to become much more severe as climate change advances.

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Impacts on alpine ecosystems

Because the Himalayan mountains are young and still rising, they are unusually vulnerable to topographic instability. The spread of early successional species, including alien invasive species following landslides, may greatly restrict the normal vegetation shifts. The disappearance of snowpack and glaciers will affect species composition and biogeochemistry from local to continental scales, and interfere with other ecological drivers (Singh and Singh, 1992). Warming and resulting desiccation (warming will increase the drying power of the atmosphere) will make grasslands and peatlands prone to fire and depletion of soil. because of the occurrence of diverse plant functional types (e.g. both evergreen and deciduous woody plants, tall and rosette herbs, mosses and lichens), shifts in communities will result in a complex series of changes in ecosystem processes with a considerable involvement of the soil subsystem.

Spread of diseases

A warmer and highly variable climate can affect human health in various ways, both directly and indirectly. For example, it can increase the transmission of diseases to new areas by adversely affecting agricultural production and causing malnutrition in some of the least developed countries, including those in the Himalayan region. It can decrease water supply in warm seasons and increase disease load, and cause hazardous extreme weather. Estimating the impact of climate change on human health in any one area is difficult, although a number of trends are clear. The people who are likely to bear most of the burden of disease are the poor, particularly children and women. In mountains women and children often make up the bulk of the population in villages where outmigration of males in search of employment is high.

Impacts on agriculture in the Himalayas

Without doubt one of the major consequences of climate change is going to be the change in crop selection and increase in the altitudinal range of cultivated land. Delay in snowfall and early snow melt may encourage people to cultivate crops in alpine meadows: for example, crops like potato may expand to become a regular feature at what are now Alpine altitudes. Equally clearly, since about 90 per cent of agriculture in the Himalayas is rain-fed, agriculture is going to be severely affected in Western ranges (Vedwan and Rhoades, 2001) by more frequent and intense droughts caused by the increased drying power of the atmosphere.

Planned adaptation to climate change in the Himalayas

Human beings adapt, for better or for worse, to a changing climate. They may migrate, they may switch to other agricultural crops, or they may change their cropping technology (spraying the apples more often). They may also suffer and die from diseases that are a direct result of global warming. But there are ways in which adaptation can be assisted, and assisted along a route that is positive both for human welfare and for the environment. The problem is that such adaptation often requires funds that are not available locally. Although the possibility for

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international funds for climate adaptation exists under the United Nations Framework Convention on Climate Change (UNFCCC), negotiations on this have been proceeding rather slowly and the funds so far pledged are very limited. The international community under the UNFCCC and the Kyoto Protocol has given more attention to mitigation activities because this is a sector in which money can be earned at many levels. But there are mitigation activities that could also help to support positive adaptation, and combining these two climate-related functions may be the most efficient way to proceed. The need for an integrated approach in dealing with adaptation in Nepal has already been outlined by Gurung and Bhandari (2008). Two such possibilities for the Himalayas in general are briefly mentioned here.

The first concerns soil organic matter

With global warming, there is likely to be enhanced decomposition of soil organic matter and release of CO_2. Since 1850, 160 million metric tonnes of CO_2 have been emitted from soils and biomass worldwide (Paustian *et al*., 2006). However, through technology agricultural soils can be made net CO_2 accumulators by increasing productivity, improving cropping practices, using erosion control measures and reducing tillage. In much of the Himalayas, forest floor litter is collected and composted along with livestock dung. The partly decomposed organic matter is then transported to crop fields while preparing beds for seed sowing. In recent years some progress has been made in the region in promoting vermicomposting, which markedly improves nutrient delivery to crop plants. It is possible to further improve internal nutrient control in a cropland with the assistance of soil microbes. These practices can reduce the use of chemical fertilizers and hence GHG emissions associated with their manufacture. There are no possibilities for carbon crediting for reduced emissions in agriculture under the Clean Development Mechanism, but the UNFCCC is beginning to discuss a much broader Agriculture, Forestry and Land Use policy that, if agreed upon, could provide the financial basis for these kinds of interventions. Low- and no-tillage practices that help soil carbon accumulation in cereal production might also be included.

The second concerns carbon forestry. The Indian Himalayan forests alone contain about 5.4 billion tonnes of carbon and sequester nearly 65 million tonnes of carbon per year, largely as a result of forest management activities carried out by local people in Van Panchyats (village forests) (Singh, 2007). This amount of carbon sequestered per year is equivalent to about 15 per cent of the CO_2 emissions from fossil fuels combustion from India in the year 2000. Obviously, the Himalayan region contributes substantially to the country level carbon budget. A study carried out under the project 'Kyoto: Think Globally Act Locally' indicates that well-managed community forests in Uttarakhand sequestered 3.7 tonnes of carbon (13.32 tonnes of CO_2) per hectare per year, in addition to meeting the day-to-day needs of villagers for firewood, fodder and leaf litter, among other things (Banskota et al., 2008). A programme promoting fodder production

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from grasses and legumes could substantially reduce the lopping of branches to gather leaves for fodder, and hence contribute to increasing the carbon sink as well as improving dairy production. At present, local people who manage these forests are not paid for this carbon function, but with new policy being developed under the UNFCCC, Reducing Emissions from Deforestation and Degradation (REDD), a possibility for this may be opened, particularly if REDD policy covers not only reductions in degradation but also enhancement of forests, an option that is now under discussion in an expanded form of REDD known as REDD+. Sale of carbon credits generated by communities in the Himalayas through managing their forests sustainably could help in the diversification of local income as other opportunities decrease as a result of climate change.

Impacts of climate change on forest, meadows and mountain ecosystems

Impacts can be inferred based on responses of limited species/area to factors such as higher temperatures and CO_2 levels, and on differentiation of ecosystem in space as related to climatic variability. One way of assessing the impacts of climate change could be to make an inventory of landcover changes and identify their causal factors. Such an approach showed a greater influence of non-climate factors compared to climate factors in Himalaya. Indeed, farmers' perceptions are likely to be biased towards responses of agricultural crops, components of natural ecosystems that affect their livelihood or that are very conspicuous such as *Rhododendron arboretum* with mass production of large red flowers. Advancement of flowering in *R. arboreum* and upward expansion of *Tagetis minuta*, *Lantana camara* and *Eupatorium* spp. seem to be driven primarily by climate change. Nonetheless, possibility of modification of climate change driven changes by those driven by non-climate factors cannot be ruled out.

Conclusion

Climate change no longer remains a distant theoretical possibility or an academic rhetoric; but is an unconcealed reality. It is perceived as the most critical environmental and developmental challenge faced by humanity today. The deep interconnections between the vulnerability of natural and human systems to climate change calls for expeditious coping strategies and response measures. Uttarakhand is most vulnerable to climate mediated risks. Mountainous regions are vulnerable to climate change and have shown "above average warming" in the 20th century. According to the Intergovernmental Panel on Climate Change (IPCC), impacts are expected to range from reduced genetic diversity of species to glacial melt in the Himalayas leading to increased flooding that will affect water resources within the next few decades. The climate response strategy of Uttarakhand should have key elements such as accelerating inclusive economic growth, promoting sustainable development, securing and diversifying livelihoods, and safeguarding ecosystem services. Further, the strategy should not be viewed as a standalone action; instead it should be integrated into the regular developmental planning process.

Similarly, while it is important to pursue both mitigation and adaptation measures, considering the overall socio-economic and ecological contexts and vulnerabilities, it would be of importance to give priority to adaptation options including Disaster Risk Reduction. Adaptation needs to be the predominant philosophy and component of the climate response strategy of Uttarakhand.

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